Growth and Characterization of InGaN/GaN Quantum Dots for violet-blue Applications

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We report on plasma-assisted molecular beam epitaxy growth and characterization of InGaN/GaN quantum dots (QDs) for violet/blue applications.

The growths were performed on 4µm thick (0001) GaN-on-sapphire templates. Prior to QDs growth, a GaN buffer layer, ~100 nm thick was grown at ~700 ºC, under intermediate Ga-rich conditions to burry possible impurities and to provide flat surface. The targeted 20% In content for QDs growth was calibrated by growth of thin (~20 nm) compact InGaN layers, varying growth temperature and Ga/N flux ratio. The In content in the compact layers was estimated by X-ray diffraction technique. The InGaN QDs were grown at 580 ºC with the nitrogen flux set to 3 nm/min (in (0001) GaN equivalent growth rate units) and the Ga flux set to 50% of the nitrogen flux value. The In flux was varied until the effective stoichiometry (conditioned by InN decomposition and In desorption) was achieved. To provide stable In adlayer coverage (and thus avoid transient effects), two monolayers (MLs) of metallic indium were deposited prior to growth of 4 InGaN MLs. Then, the sample was left either in vacuum or under active nitrogen flux for typically 60s before the growth temperature was sharply decreased. When 2 MLs In excess was desorbed, the Stransky-Krastanov transition occurred, as confirmed in-situ by RHEED. Both single uncovered InGaN/GaN QD layers and three-period InGaN/GaN QD super-lattices, covered by 30 nm GaN cap layer, were grown.

Depending on growth conditions, dot and ring morphology can be distinguished, as confirmed by atomic force microscopy (AFM), the later being linked to lower adatom surface mobility. The dots were typically formed at the edge of atomic terraces, with height of 2-3 nm, diameter of 20-30 nm and density of ~5×10^{10} cm^{-2} (Fig 1).

Low temperature photo- and cathodoluminescence revealed InGaN peak around 440 nm, with a typical full width of half maximum of ~25 nm (~16 meV) (Fig 2).

The samples are currently under time-resolved photoluminescence and transmission electron microscopy examinations.

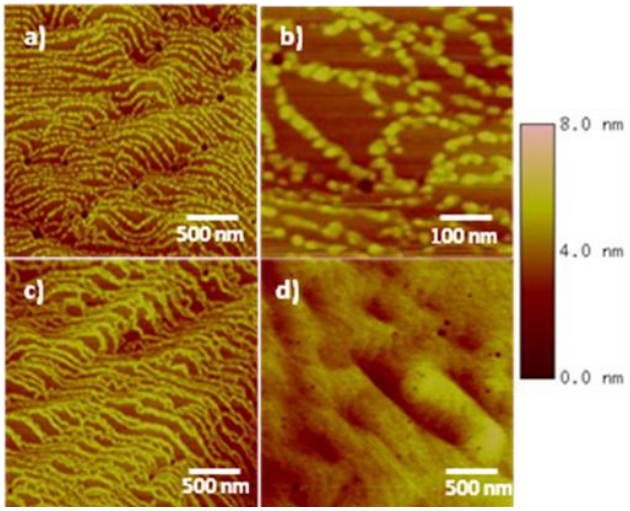

Fig 1: AFM images of different surface morphologies: (a)-(b) dot and (c) ring morphology. Reference (d) GaN surface and (right) height scale

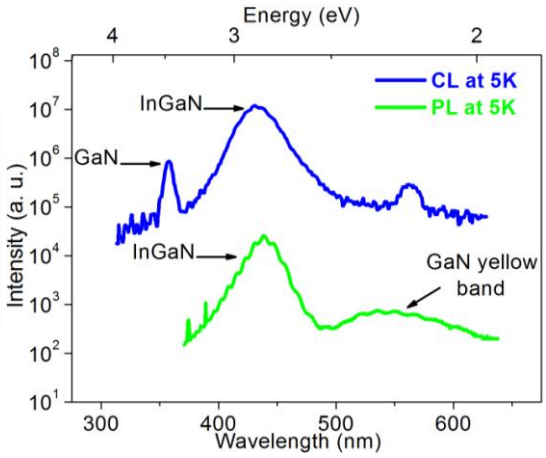

Fig 2: Low-temperature photoluminecsce and cathodoluminescence of a three-period InGaN/ GaN QD super-lattice.